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LATEST TRENDS IN ANTI TANK GUIDED WEAPONS

Introduction

1. The history of missile can be traced to 13th century when Chinese used the first rocket missile. But the guided missile originates from the German V-1 and V-2 rockets, which were effectively used to bombard London during Second World War. In July 1944, three weeks after German V-1 “Buzz Bombs” struck England, American engineers began an extraordinary effort to “reverse-engineer”. Seventeen days after receiving damaged components salvaged from English crash sites America’s first unmanned guided missile, a working copy of the V-1 was fired at Wright Field, Ohio. Then they designed JB-2 (Jet Bomb-2). The JB-2 played a significant role in the development of surface-to-surface missile systems.

2. Guided missile is a space traveling unmanned vehicle, which carries with in it self the means for controlling the path of the missile. The control is done so that the missile can hit its target. So actually it is the control system of the missile, which keeps the missile on its path, till the time missile hit the target. When ever the missile deviates from its path an error signal is generated this causes change in the missile path.

3. The science of warfare now has a new area which deals with the push button warfare. Now it is possible to destroy a city by just pushing the button that would launch a guided missile. The guided missile, with destructive intent, can hit a target, while remaining at a relative safe distance.

Guided Missile

4. A guided missile is a space traveling unmanned vehicle, which carries within itself the means of controlling it. Guided missiles are made up of a series of subassemblies (figs.1.1). The various subassemblies form a major section of the overall missile to operate a missile system, such as guidance, control, armament (warhead and fuse), and propulsion. The major sections are carefully joined and connected to each other. They form the complete missile assembly. The arrangement of major sections in the missile assembly varies, depending on the missile type. The major sections are :

a. Guidance section.

b. Control section.

c. Propulsion section.

d. Armament section.

5. **Guidance Section.** The complete missile guidance system includes the electronic sensing systems that initiate the guidance orders and the control system that carries them out. The elements for missile guidance and missile control can be housed in the same section of the missile, or they can be in separate sections. The task of the guidance system is to detect whether the, missile is flying too high or too low, or too much to the right or left. It measures these deviations or errors and issues commands to the control system to maneuver to reduce these errors to zero. A guidance system is used to keep the missile on its proper flight path and headed toward the target. The guidance system can be thought of as the brain of the missile.

6. **Control Section.** The task of the control system therefore is to maneuver the missile quickly and efficiently as a result of commands from the guidance system. The control system performs two distinct tasks. First, it maintains the missile in proper flight

attitude. Using instruments like gyros, the control system corrects for problems experienced through rotation and translation. Second, the control system responds to orders from the guidance system and steers the missile toward the target.

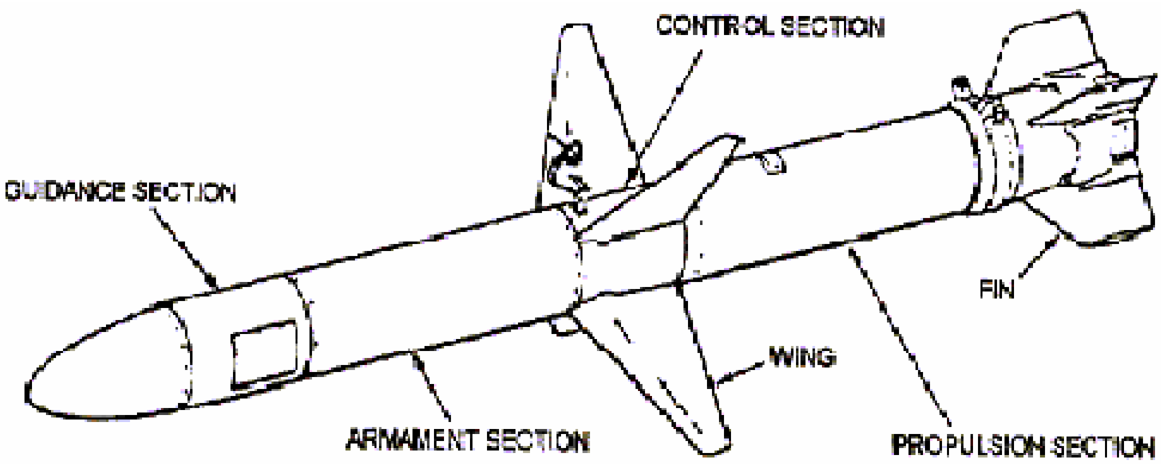


Figure 1.1: Missile Components

7. **<u>Propulsion Section</u>.** Guided missiles use some form of jet power for propulsion. “Propulsion” is defined as the act of driving forward or onward by means of a force that imparts motion. There are two basic types of jet propulsion power plants used in missile propulsion system. The atmospheric and the thermal jet propulsion systems. The basic difference between the two systems is that the atmospheric jet engine depends on the atmosphere to supply the oxygen necessary to start and sustain burning of the fuel. The thermal jet engine operates independently of the atmosphere by starting and sustaining combustion with its own supply of oxygen contained within the missile.

a. **Atmospheric Jet Propulsion System**. There are three types of atmospheric jet propulsion systems are the turbojet, pulsejet, and ramjet engines. A typical turbojet engine includes an air intake, a mechanical compressor driven by a turbine, a combustion chamber, and an exhaust nozzle. The engine does not require boosting and can begin operation at zero acceleration.

b. **Thermal Jet Propulsion System.** Thermal jets include solid propellant, liquid propellant, and combined propellant systems. The solid propellant and combined propellant systems are currently being used in some air-launched guided missiles. The majority of air-launched guided missiles use the solid propellant rocket motor. They include the double base and multibase smokeless powder propellants as well as the composite mixtures. Grain configurations vary with the different missiles. Power characteristics and temperature limitations of the individual rocket motors also vary. In some guided missiles, different thrust requirements exist during the boost phase as compared to those of the sustaining phase.

8. **Armament Section.** The armament system contains the payload (explosives), fuzing, safety and arming (S&A) devices, and target-detecting devices (TDDs).

a. **Payload.** The payload is the element or part of the missile that does what a particular missile is launched to do. The payload is usually considered the explosive charge, and is carried in the warhead of the missile. High-explosive warheads used in air-to-air guided missiles contain a rather small explosive charge, generally 10 to 18 pounds of H-6, HBX, or PBX high explosives. The payload contained in high explosive warheads used in air-to-surface guided missiles varies widely, even within specific missile types, depending on the specific mission. Large payloads, ranging up to

450 pounds are common. Comp B and H-6 are typical explosives used in a payload. Most exercise warheads used with guided missiles are pyrotechnic signaling devices. They signal fuze functioning by a brilliant flash, by smoke, or both. Exercise warheads frequently contain high explosives, which vary from live fuzes and boosters to self-destruct charges that can contain as much as 5 pounds of high explosive.

b. **Fuzing**. The fuzing and firing system is normally located in or next to the missile's warhead section. It includes those devices and arrangements that cause the missile's payload to function in proper relation to the target. The system consists of a fuze, a safety and arming (S&A) device, a target-detecting device (TDD), or a combination of these devices. There are two general types of fuzes used in guided missiles-proximity fuzes and contact fuzes. Both fuzes are armed by acceleration forces upon missile launching. Arming is usually delayed until the fuze is subjected to a given level of accelerating force for a specified amount of time. In the contact fuze, the force of impact closes a firing switch within the fuze to complete the firing circuit, detonating the warhead. Where proximity fuzing is used, the firing action is very similar to the action of proximity fuzes used with bombs and rockets.

c. **Safety and Arming (S&A) Devices**. These devices are electromechanical, explosive control devices. They maintain the explosive train of a fuzing system in a safe (unaligned) condition until certain requirements of acceleration is met after the missile is fired.

d. **<u>Target Detecting Devices (TDD)</u>.** TDDs are electronic detecting devices similar to the detecting systems in fuzes. They detect the presence of a target and determine the moment of firing. When subjected to the proper target influence, both as to magnitude and change rate, the device sends an electrical impulse to trigger the firing systems. The firing systems then act to fire an associated S&A device to initiate detonation of the warhead. Air-to-air guided missiles are normally fuzed for a proximity burst by using a TDD with an S&A device. In some cases, a contact fuze maybe used as a backup. Air-to-surface guided missile fuzing consists of proximity or contact fuzes. Multifuzing is common in these missiles.

e.

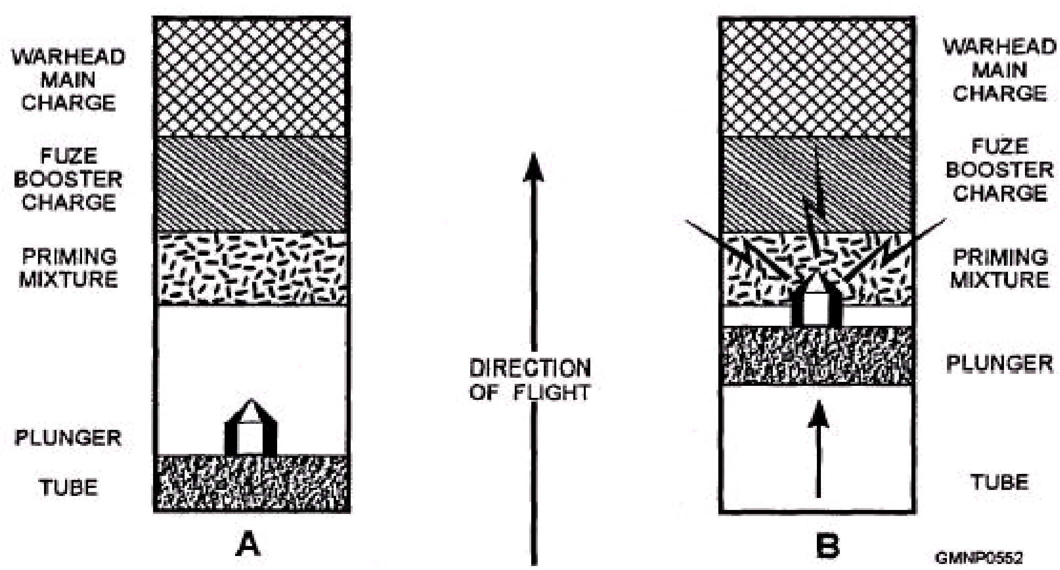


Figure 1.3: Contact fuze action: A. Before impact; B. After impact.

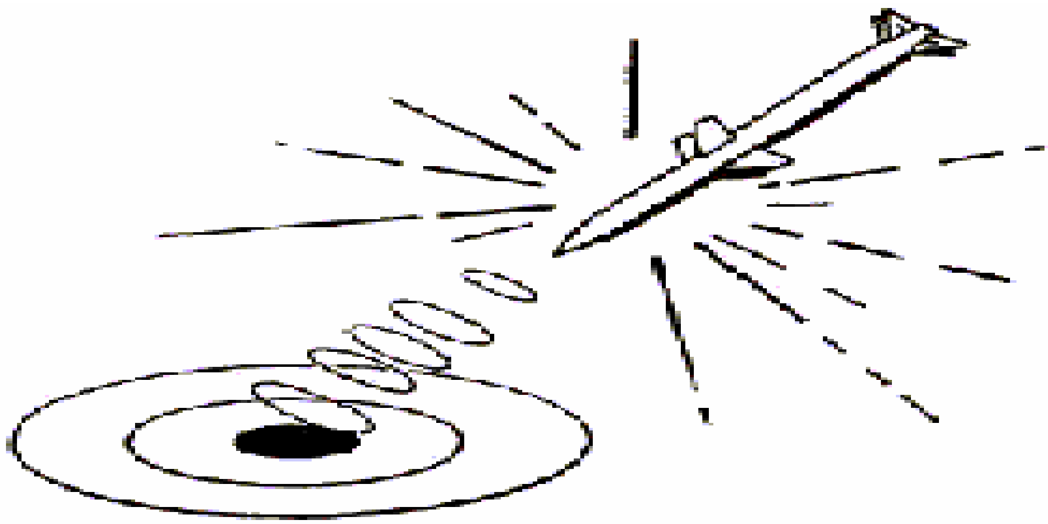


Figure 1.4: A proximity fuze

Missile Guidance System

9. **<u>Guidance</u>.** The complete missile guidance system includes the electronic sensing systems that initiate the guidance orders and the control system that carries them out. A weapon should have a single shot kill probability as high as possible. Unguided weapons may fail in this respect due to;

a. Excessive miss distance due to incorrect launching direction of the missile.

b. Unpredicted movement of the target after launching of the missile.

c. Missile path affected by wind or weather.

10**.** **<u>Phases of Guidance</u>**. Generally, missile in-flight guidance is divided into three phases i.e. the boost, midcourse, and terminal phase. These names refer to the different parts or time periods of a trajectory.

a. **<u>Boost Phase</u>.** The boost phase of missile flight is also known as the launching phase or initial phase. It is during this period that the missile is boosted to flight speed. It lasts until the fuel supply of the booster bums up.

b. **<u>Midcourse Phase</u>.** The second or midcourse phase of guidance is often the longest in both distance and time. During midcourse guidance, the missile makes any corrections necessary to stay on the desired course.

c. **<u>Terminal Phase</u>.** The terminal phase of guidance brings the missile into contact or close proximity with the target. The last phase of guidance must have quick response to ensure a high degree of accuracy. Quite often the guidance system causes the missile to perform what is best described as an “up-and-over” maneuver during the terminal phase. Essentially, the missile flies higher than the target and descends on it at intercept.

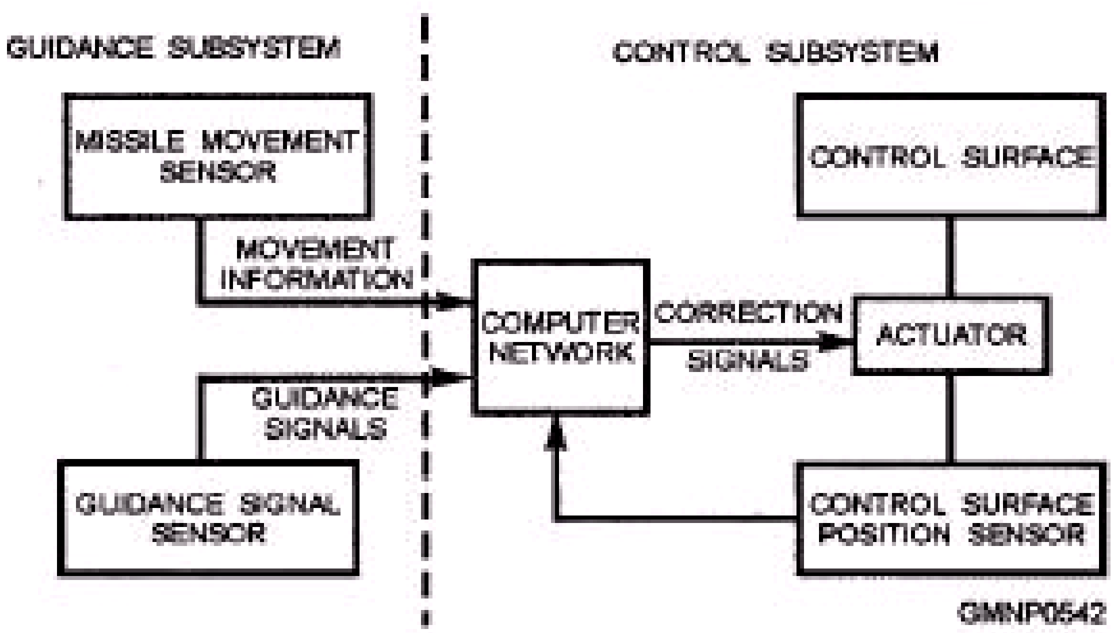


Figure 2.1: Basic missile guidance system

11. **Methods Of Guidance.** Military missile systems use a variety of methods to guide the missile to its intended target. These can generally be classified into a number of categories, with the broadest categories being active vs. passive vs. preset.

a. Passive systems use signals generated by the target itself as a signal on which to “home in”. A number of such systems have been developed, but by far the most common are sound in the case of torpedoes and infrared in the case of ground launched missiles.

b. Active systems use some “input” signal instead. One common sort of signal is a controller who watches the missile and sends corrections to its flight path. Another common system is to use radar signals or radio control. The semi-active radar homing is a crossover, homing passively on a reflected active radar signal generated by some other system.

c. Preset systems are used to attack targets at fixed locations, such as military bases and cities. In this system a fixed grid reference and the path for the guided missile is fed into the missile and the missile then follows its preset path down to the target.

12. **Types of Guidance System**

a. **Inertial Guidance.** The inertial guidance method is similar to the preset guidance method. Inertial guided missiles also receive preprogrammed information before launch. After launch, there is no electromagnetic contact between the missile and its launch point However, unlike preset guidance, the missile can make corrections to its flight path and does so with amazing accuracy. Flight control is accomplished by using special sensors, called accelerometers, mounted on a gyro-stabilized platform. All in-flight accelerations are measured continuously and the guidance and control systems generate steering orders to maintain the proper trajectory. The unpredictable outside forces (e.g., wind) are also monitored by the sensors.

Correction orders are generated to maintain proper flight attitude. inertial guidance uses sensitive measurement devices to calculate the location of the missile due to the acceleration put on it after leaving a known position. Early mechanical systems were not very accurate, and required some sort of external adjustment to allow them to hit targets even the size of a city. Modern systems use solid state ring gyros that are accurate to within metres over ranges of 10,000km, and no longer require additional inputs.

b. **Self-Contained Guidance Systems.** Certain guided missiles have self-contained guidance systems. All guidance and control functions are performed totally within the missile. They neither transmit nor receive any signals during flight. Therefore, jamming or other electronic countermeasures are ineffective against them. Generally, self-contained guidance systems are used in surface-to-surface or shore applications.

c. **Preset Guidance.** The term preset completely describes this method of guidance. Before the missile is launched, all the information relative to target location and the required missile trajectory must be calculated. The data is then locked into the guidance system so the missile will fly at correct altitude and speed. Also programmed into the system are the data required for the missile to start its terminal phase of flight and dive on the target. One disadvantage of preset guidance is that once the missile is launched, its trajectory cannot be changed. Therefore, preset guidance is really only used against large stationary targets, such as cities.

d. **Navigational Guidance Systems.** When targets are at very great distances from the launch site (beyond the effective range of radar, for example), some form of navigational guidance must be used. Accuracy at these distances requires exacting calculations and many complicated factors must be considered. Three types of navigational guidance systems that may be used by long-range missiles are inertial, celestial, and terrestrial.

e. **Celestial Guidance.** A celestial guidance system uses stars or other celestial bodies as known References in determining a flight path. This guidance method is rather complex and cumbersome. However, celestial guidance is quite accurate for the longer ranged missiles.

f. **Terrestrial Guidance.** Terrestrial guidance is also a complicated arrangement. Instead of celestial bodies as reference points, this guidance system uses map or picture images of the terrain which it flies over as a reference. Terrestrial and celestial guidance systems are obviously better suited for large, long-range land targets.

g. **Command Guidance Systems.** Command guidance involved tracking the projectile from the launch site or platform and transmitting commands by radio, radar, or laser impulses or along thin wires or optical fibers. Tracking might be accomplished by radar or optical instruments from the launch site or by radar or television imagery relayed from the missile. All guidance instructions, or commands, come from outside the missile. The guidance sensors detect this information and convert it to a usable form. The output of the guidance computer initiates the movement of the control surfaces and the

missile responds. There are (or were) various types of command guidance methods. Early examples included remote control by wire and by radio command. Generally command by wire was limited to air-launched missiles. A pair of fine wires was unrolled from coils after the missile was launched. The airplane pilot mentally calculated and manually controlled the trajectory of the missile to the target. Radio command eliminated wires and extended the range of a missile. However, one solution always leads to another problem. Radio command was effective as long as the operator could see the missile. After it flew beyond the range of normal vision well, you can understand the problem if you have ever owned a remote-controlled model airplane. From wire, to radio, to the next logical method-radar.

h. Figure 2.3 shows the basic arrangement of radar command guidance. As soon as radar #1 (target tracker) is locked on target, tracking information is fed to the computer. The missile is launched and tracked by radar #2 (missile tracker). Data from both target and missile radars, such as ranges, elevations, and bearings, are fed continuously into the computer. The computer analyzes the data and determines the correct flight path for the missile. The guidance signals or commands generated by the computer are routed to a command (radar or radio) transmitter and sent to the missile. The receiver of the missile accepts the instructions, converts them, and directs the control surfaces to make steering corrections.

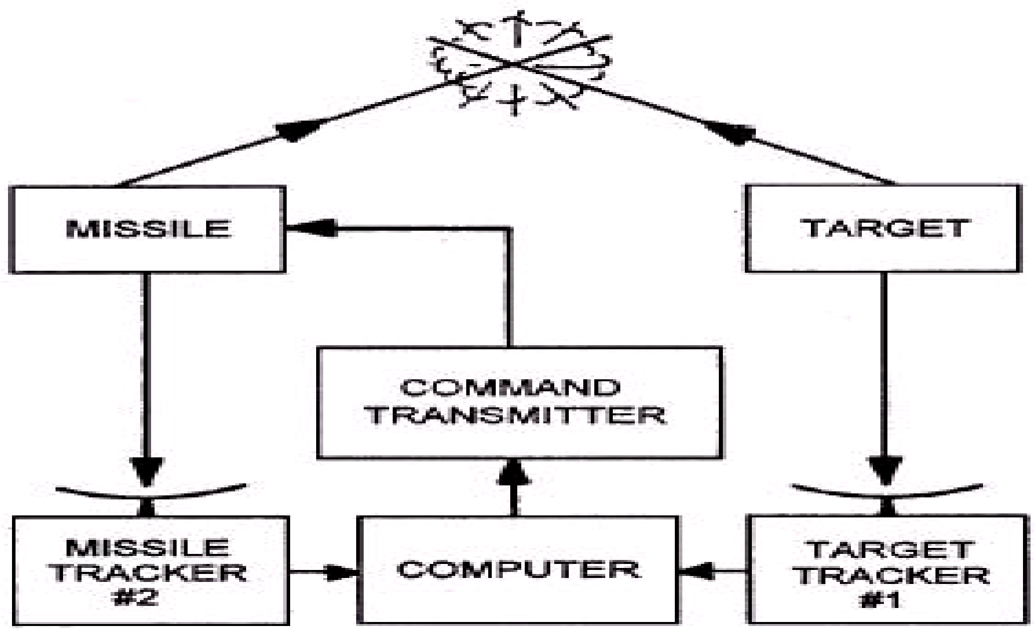


Figure 2.3: Basic radar command guidance

(1). **<u>MCLOS</u>.** Manually command to line of sight, the operator watches the missile flight and uses some sort of signaling system to command the missile back into the straight line between the operator and the target (the "line of sight"). Typically useful only for slower targets where significant "lead" is not required. MCLOS is a subtype of command guided systems.

(2). **<u>SACLOS</u>.** semi-automatic command to line of sight, is similar to MCLOS but some automatic system positions the missile in the line of sight while the operator simply tracks the target. SACLOS has the advantage of allowing the missile to start in a position invisible to the user, as well as generally being considerable easier to operate.

(3). **<u>ACLOS</u>.** Automatic command to line of sight, is a system in which the missile tracks the target by either emitting its own electromegnatic radiatioins and then receiving them back while the target is in own line

of sight. The system does not require any input from the gunner or the firer but is self contained.

(4). **<u>Line Of Sight-Beam Riding</u>.** In a LOS-BR System target tracking is required, but instead of a missile tracker, a laser or a radar beam is projected along the sight line. The beam is constrained to describe a precise pattern immediately about its axis, such that a detector at the back of the missile can tell exactly how far off the sightline it is. The missile electronics calculate the correction and generate the siignals to the missile control mechanism to maintain itself on the sight line.

j. **<u>Homing Guidance Systems</u>.** Homing guidance systems also rely on electromagnetic radiations for guidance information. The homing device is usually a small antenna located within the nose of the missile. It detects some type of distinguishing feature or radiation given off by or reflected from the target. This information is converted into usable data and positions the control surfaces. Three types of homing guidance systems are used by SMS missiles-active, semi active, and passive.

(1). **<u>Active Homing Guidance</u>.** In active homing guidance (view A of fig. 2.4), the missile contains an onboard transmitter and receiver. The transmitter sends out radar signals in the general direction of the target. These signals strike the target and reflect or bounce back to the missile. These return “echoes” are picked up by the receiver antenna of the missile and fed to the guidance computer. The computer output generates steering corrections for the control system. Active homing guidance does not require ground radar; the missile is entirely on its own after launch.

(2). **<u>Semi Active Homing Guidance</u>.** In semi active homing guidance (view B of fig. 2.4), the missile contains only a receiver (referred to as a seeker head or signal antenna). The ground fire control radar serves as the transmitting source and directs its radar energy to illuminate the

target. As in active homing guidance, part of this energy is reflected or bounced from the target. The receiver of the missile picks up the reflected energy and uses it to generate its own steering commands.

(3). **Passive Homing Guidance.** The passive homing guidance method (view C of fig. 2.4) depends on the missile's detecting some form of energy emitted by the target. A receiver antenna inside the missile picks up this "signal" and computes all necessary guidance information. Steering corrections are made and the missile homes in on the target.

Anti Tank Guided Missile

13. An Anti-tank guided missile (ATGM) or weapon (ATGW) is a guided missile primarily designed to hit and destroy tanks and other armoured fighting vehicles. ATGMs range in size from small shoulder-launched portable weapons, to very large vehicle- or aircraft-mounted missiles capable of defeating the heaviest tank armour.

14. Command guided missiles are guided manually (MCLOS) or semi-automatically (SACLOS). Guidance commands are sent to the missile through wires or radio. More advanced guidance systems rely on laser marking or a TV camera view from the nose of the missile, and some of the latest models are "fire-and-forget" and even "fire-and-fix".

15. Most ATGMs have shaped-charge HEAT warheads, designed specifically for penetrating armour. Double-warhead missiles attempt to defeat very heavy or spaced vehicle armour. Top-attack weapons are designed to focus the explosion down through an AFV's thinner top armour. Anti-tank weapons like Bazookas and RPGs are not considered ATGMs since they don't have any guidance system.

<u>Guidance in missiles</u>.

16. ATGMs can be guided into the target by several methods, such as laser guiding, laser marking, TV camera, wire-guiding etc. The most advanced ATGMs have options for “fire-and-forget” and even “fire-and-fix”. Anti-tank weapons like Bazookas and RPGs are not considered ATGMs since they don’t have any guidance system. There are some similarities between guided missiles and guided bombs. A guided bomb, dropped from an aircraft, is unpowered and uses aerodynamic fins for forward horizontal maneuvering while falling vertically.

17. Missiles that have the ability to maneuver through the air can be guided, and are known as guided missiles. These have three key system components:

a. Tracking

b. Guidance

c. Flight

a. A tracking system locates the missile’s target. This can be either a human gunner aiming a sight on the target (remotely from the missile) or an automatic tracker. Automatic trackers use radiation emanating from the target or emitted from the launch platform and reflecting back to it from the target. Passive automatic trackers use the target’s inherent radiation, usually heat or light, but missiles designed to attack Command & Control posts, aircraft or guided missiles may look for radio waves. Active automatic trackers rely on the target being illuminated by radiation. The target can be “painted” with light (sometimes infrared and/or LASER) or radio waves (radar) which can be detected by the missile. The radiation for the painting can originate in the missile itself or may come from a remote station (for example, a hilltop gunner can illuminate a target with a LASER device and this can be used to direct an air launched guided missile).

b. A guidance system takes data from the missile's tracking system and flight system and computes a flight path for the missile designed to intercept the target. It produces commands for the flight system.

c. The flight system causes the missile to maneuver. There are two main systems: vectored thrust (for missiles that are powered throughout the guidance phase of their flight) and aerodynamic maneuvering (wings, fins, canards, etc).

18. **ATGW Requirements.**

a. Accuracy.

b. Simplicity.

c. Resistance to counter measures.

d. Minimal mutual interference.

e. All weather, day and night capability.

f. Light weight and small volume.

g. Cheapness.

19. **Evolution of Anti Tank Guided Missiles.** Anti tank guided missiles have undergone many evolution phases. Ever since armour played a major role in the second world war, the need of effective anti tank weapons became all the more important. The best answer towards anti tank tactics was the use of anti tank guided missiles. These missiles were more reliable and effective against and any tank. Over the years these anti tank guided missiles have undergone many phases of evolution, from being guided

manually to them being fire and forget has taken a giant leap in anti tank warfare. The various generations of anti tank guided missiles are:

a. **First Generation Anti Tank Guided Weapons.** The first generation anti tank guided missiles involved guiding the missile through MCLOS. The French were the first in the field with the SS10 ATGW, introduced in 1955.The British followed suit with the development of Orange William (AFV mounted) and Vigilant (infantry ATGW). The Australians developed Malkara. Later Swingfire entered into service with the British Army in 1969. These missiles could be guided manually with the help of the unwound wire at the back of the missile just like steering a kite in air or through radio transmission which is like flying a small modal airplane.

b. **Second Generation Anti Tank Guided Missiles.** The major development in second generation ATGW was the adoption of SACLOS rather than MCLOS, guidance. When a target is chosen, the soldier who directs the missile must paint the target during the duration of the missile's flight. These generation of missiles also includes "laser guided" missiles. Examples of semi-automatic ATGW are ‘HOT’ and ‘Milan’ built by the Franco-Germany consortium; the US systems ‘TOW’, ‘TOW2’, ‘TOW2A’, ‘TOW2B’, ‘Hellfire’ (laser guided) and ‘Dragon’; the Swedish ‘Bill’; the Russian ‘AT-3’ (SAGGER), ‘AT-4’ (SPIGOT), ‘AT-5’ (SPANDREL), ‘AT-6’ (SPIRAL), ‘AT-2’ (SWATTER C), ‘SU25ATK’, ‘AT-8’, ‘AT-10’ and ‘AT-11’; the Israeli ‘Mapatz’ (laser guided)and LAHAT Laser Guided Missile.

c. **Third Generation Anti Tank Guided Missiles**. The third generation Anti tank guided missiles use ACLOS, and other Homing techniques in order to engage their target. These are basically "Fire and forget" missiles. Fire and forget is the military term for a type of missile which does not require further guidance after launch such as illumination of the target, and can hit its target without the launcher being in line of sight of the target. Generally, information about the target is programmed into the missile just prior to

launch. This can include coordinates, RADAR measurements (including velocity), or an IR image of the target. After it is fired, the missile guides itself by some combination of gyroscopes, GPS, RADAR, and infra red optics. Some systems offer the option of either continued input from the launch platform or fire-and-forget. These missiles are essentially independent from the moment of launch, or, once a missile "lock" has been established. Examples of these systems are the US's Javlin; British NLAW, Trigat IR Missile; Indian Nag; Russian Ataka Missile, Shturm Self Propelled Anti-Tank Guided Missile System, 9K116 Bastion, AT-X-14 Kornet, AT-X-15 Krizantema, AT-X-16 Vikhr (Aircraft Mounted); China's Hong Jian-9 (Hj-9), AT-10 Stabber, AT-11 Sniper, and AT-12 Sheksna. In addition to the above-mentioned missiles, there are advanced variants which are optically guided via a camera that broadcasts images of the target from the perspective of the missile, thereby enabling the soldier to direct the missile with pinpoint accuracy. Examples are US's LOSAT, EFOGM fiber-optic guided missile and YMGM-157B; Israel's GILL/SPIKE Electro-Optical and Fiber-Optic missile, NTD (Spike-Er); Polyphem by EU.

Existing Trenda In Anti Tank Guided Missiles.

Wire Guided Missiles.

21. A wire-guided missile is a missile guided by signals sent to it via thin wires reeled out during flight. This guidance system is most common for anti-tank missiles, where its ability to be used in areas of limited line-of-sight make it useful, while its limited maximum range, that of the wires, is not a serious concern.Wire guidance is obviously limited by the length of the wire; the longest-ranged wire-guided missile in current use are limited to about 2.5 miles; the Tube-Launched, Optically Tracked, Wire-Guided Missile System (TOW), with a range of 3750 m

22. Wire guidance was first employed by the Germans during World War II. Most of their developments used radio control, but as the British proved to be able to jam anything they used, rushed projects were started in 1944 in order to develop alternatives. The first system to be modified in this fashion was the Henschel Hs 293B anti-shipping missile, but by the time it was ready it was too late to be useful as the Allies had already landed strong forces in France. Other examples included the X-4 anti-aircraft missile, and the X-7 anti-tank version of the X-4.

23. In the post-war era it was the X-7 that had the most effect on other military thinkers. By the early 1950s a number of experimental systems had been developed (see, e.g. Malkara missile), leading to their widespread deployment in the late 1950s and early 1960s. Large numbers of Israeli tanks were destroyed using wire guided missiles during the Yom Kippur War of 1973. Wire guidance has remained the main system for most smaller weapons, although newer systems such as laser beam riding have come into use in anti-aircraft and some anti-tank use roles, e.g. the US Hellfire missile).

Radio Command Guided Missiles.

Latest trends in Anti Tank Guided Missiles.

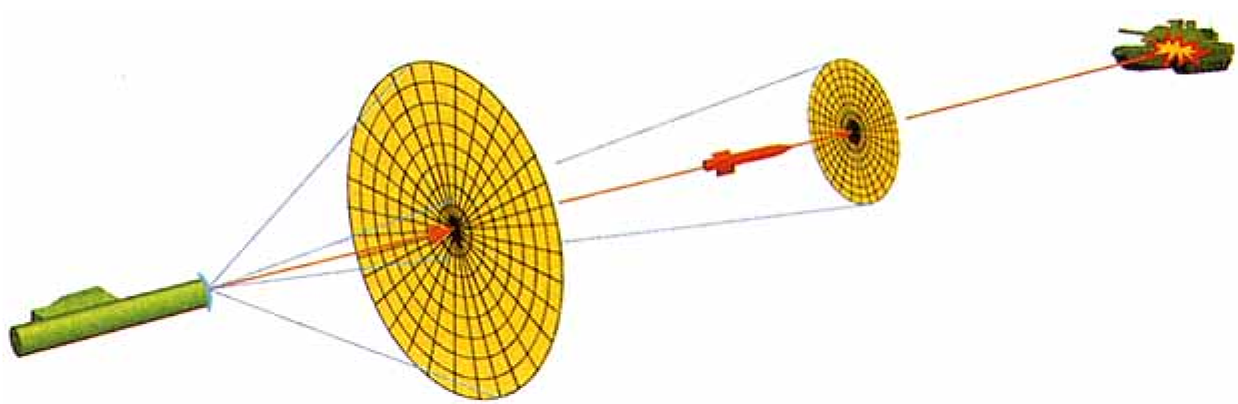
Beam Riding.

24. Beam riding, in which a “beam” of some sort, typically radar, radio or laser, is pointed at the target and detectors on the rear of the missile keep it centered in the beam. Beam riding systems are often SACLOS, but don’t have to be, in other systems the beam is part of an automated radar tracking system.

25. The main use of this kind of system is to destroy tanks and other armoured vehicles. First, an aiming station (possibly mounted in a vehicle) in the launching area directs a narrow radar or laser beam at the enemy tank. Then, the missile is launched and at some point after launch is “gathered” by the radar or laser beam when it flies into

it. From this stage onwards, the missile attempts to keep itself inside the beam, while the aiming station keeps the beam pointing at the target. The missile, controlled by a computer inside it, “rides” the beam to the target. The aiming station can also use the radar returns of the beam bouncing off the target to track it, or it can be tracked optically or by some other means.

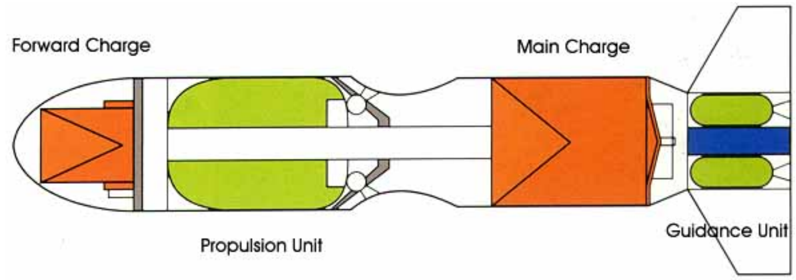
26. Laser guidance is a technique of guiding a missile or other projectile or vehicle to a target by means of a laser beam. some laser guided systems utilise beam riding guidance. A launching area consists ofa laser designator device that highlights a spot on the target with an encoded laser beam. This spot provides reference information to an incoming munition that allows it to make in-flight corrections to its trajectory. The use of an encoded signal reduces the threat of jamming as well as reducing interference in high-noise combat environments. The primary limitation on this device is that it requires a line of sight to the target from both the munition and the designator. More advanced systems use the laser to designate a target, which is acquired by an orbiting satellite that then feeds GPS target data to a launch facility. This allows potential targets to be designated long before operations commence as well as eliminating the line-of-sight requirement for the munition.



27. Examples of beam riding anti tank missiles are:

a. The British anti tank missile “TRIGAT” uses a laser beam-riding system. The laser beam is aimed at the target and the missile is launched. The seeker in the missile acquires the laser beam and guides the missile to the

target. The target must therefore be in line-of-sight and the laser must remain on target until impact. The laser beam is coded for protection against countermeasures. The thermal imaging sight employs infrared charge-coupled (IRCCD) detectors, giving day and night capability.



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b. The Chinese **"**Hong Jian-9" **(**HJ-9**)** is a long-range; laser command guided anti-tank guided missile (ATGM) system introduced for service in the PLA in the late 1990s. It is China's third-generation indigenous ATGM designed to engage and destroy main battle tanks and other armoured targets in modern battlefield. Improved variants of the HJ-9 with 'fire-and-forget' millimetre wave **(**HJ-9A**)** and laser beam-riding **(**HJ-9B) guidance are currently under development.

c. Kornet-E of Russia.

d**.** The Israeli "LAHAT".

e**.** The USA's AGM-114 Hellfire (Helicopter launched fire-and-forget) is a U.S. air-to-ground missile system designed to defeat tanks and other individual targets while minimizing the exposure of the launch vehicle to enemy fire. Hellfire uses laser guidance and is designed to accept other guidance packages. It is used on helicopters against heavily armored vehicles at longer standoff distances than any other U.S. Army missiles in the inventory.

f. Russian AT-11 Sniper, is a laser-beam riding, antitank missile launched from main gun of a tank or antitank gun. It is the successor to the earlier radio-command guidance AT-8 SONGSTER. The AT-11 can be fired by the T-72B, T-72S, T-80B, T-80U, and T-90 main battle tanks, and the 2A45M antitank gun. The 9K120 system uses beam-riding laser guidance. The tank directs a coded beam from a special gunner's sight, which creates a laser "funnel" with the missile riding in the center.

g. AT-12 Sheksna is a laser-beam riding, antitank missile launched from the main gun of an improved T-62 main battle tank.

h. Chinese/Russian AT-X-14 Kornet (the X designated that it is not yet in production) is a tripod mounted laser-beam riding antitank guided missile. The AT-X-14 is a laser beam riding missile with a semi-automatic command line of sight (SACLOS) guidance system.

j. Russian AT-X-15 Krizantema laser-beam riding antitank guided missile. It incorporates both radar and laser command guidance receivers. For the first time in the world, automatic radar target detection and tracking system, with simultaneous missile control during its guidance to the target, was developed for the Khrizantema ATGM. The unique feature of the missile is that it has two modes of guidance: automatic, where it is guided by roof-mounted radar; and by a semi-automatic laser beam rider, using the sight mounted in the front of the hull on the right side. There is no known comparable missile in the West under development or in service with a similar guidance system.

k. Russian AT-X-16 Vikhr which can be installed on a helicopter and used as an effective anti tank missile.

l. Canadian ALAWS.

m. Russian 9K116 Bastion (Tank gun fired).

n. “AT-10” Stabber of Russian origin, launched from the main gun of a T-55AM2B Chinese main battle tank.

o. MAPATS of Israel

p. Type-87 Chu-Mat Anti-Tank Missile (Semi active Laser Homing) of Japan

q. Russian Konkurs-M Laser Guided Anti Tank Missile which is now locally produced in India. It is carried on small platforms or APCs and can be rapidly dismounted for man portable land based operation. The missile can fly over water and at heights above 3,000 meters.

<u>Semi Active Laser Homing</u>.

28. This technique is sometimes called SALH, for semi-active laser homing. With this technique, a laser is kept pointed at the target and the laser radiation bounces off the target and is scattered in all directions. The missile, bomb, etc. is launched or dropped somewhere near the target. When it is close enough that some of the reflected laser energy from the target reaches it, a laser seeker notices which direction this energy is coming from and aims the projectile towards the source. As long as the projectile is in the right general area and the laser is kept aimed at the target, the projectile should be guided accurately to the target.

29. Note that laser guidance isn’t useful against targets that don’t reflect much laser energy, including those coated in special paint which absorbs laser energy. This is likely to be widely used by advanced military vehicles in order to make it harder to use laser range-finders against them and harder to hit them with laser-guided munitions.

30. The laser-guided missiles use a laser of a specific frequency bandwidth to locate the target. The pilot must line up the crosshairs and lock successfully onto target. This

laser creates a heat signature on the target. The weapon must be released during a certain window of opportunity. After it is launched, the missile uses its onboard instrumentation to find the heat signature. The target is acquired when the missile locates the heat signature. The missile is able to secure the target even if the target is moving.

31. Laser-guided missiles work by following the reflected light of a laser beam, which can either be shone on the target by the aircraft itself, by another airplane, or by ground troops with a handheld laser designator. Therefore, once the missile has been launched its own instrumentation is able to remain on target, rather than older laser-guided missiles that required the pilot to continually sight the target with the laser.

32. Laser-guided missiles are used for those targets that need pinpoint accuracy. A disadvantage of laser-guided missiles is that their guidance systems do not work well in all weather conditions. If it is cloudy, the water droplets in the air cause the laser to diffract. Because the laser only operates within a certain bandwidth, the laser can be completely diffracted if it is too cloudy and the missile will not be able to locate its target. Rain has a similar effect on the laser because each raindrop serves to diffract the laser beam, once again deterring the missile from its target.

33. Additionally, the weather limitations mentioned previously spawned a new breed of missiles that allow for accurate deployment in adverse weather conditions. Such missiles are guided using Global Positioning Satellite (GPS) technology. To guide such missiles, three coordinates are necessary: the latitude, longitude, and elevation. Developed by NASA in 2000, C-band and X-band interferometric synthetic aperture radars (ISFARs) are used to collect the topographic data required to employ this technology. NASA used these ISFARs to create the most complete and high resolution topography of the Earth available today within ten days, with guided weapons being its primary application. These missiles have a longer range than typical laser-guided missiles.

Semi-Active Radar Homing

34. Semi Active Radar Homing is an automated form of SACLOS in which the tracking radar provides a signal on which the missile homes. The signal does not nessessarily have to be pointed at the target, nor does the missile have to “ride” the beam. The missile itself is actually using passive guidance, homing on a signal reflected from the target. SALH is a similar system using a laser as a signal.

35. This is the most common type for longer range air-to-air and ground-to-air missile systems but can be incorporated in anti tank missiles also. The name refers to the missile itself being a passive detector, while an offboard radar provides a signal for the missile guidance system to “listen to” when it reflects off the target.

36. The basic concept of SARH is that almost all detection and tracking systems consist of a radar system, so duplicating this hardware on the missile itself is wasted. In addition, the resolution of a radar is strongly related to the physical size of the antenna, in the small nose cone of a missile there isn’t enough room to provide the sort of accuracy needed for guidance. Instead the larger radar dish on the ground or launch aircraft will provide the needed signal and tracking logic, and the missile simply has to listen to the signal and point itself in the right direction.

37. Contrast this with beam riding systems, in which the radar is pointed at the target and the missile keeps itself centered in the beam by listening to the signal at the rear of the missile body. In the SARH system the missile listens for the reflected signal at the nose, and is still responsible for providing some sort of “lead” guidance. The advantages are twofold. One is that a radar signal is “fan shaped” growing larger, and therefore less accurate, with distance. This means that the beam riding system is not terribly accurate at long ranges, while SARH is largely independent of range and grows more accurate as it approaches the target—the “source” of the signal it listens for. Another addition is that a beam riding system must accurately track the target at high speeds, typically requiring one radar for tracking and another “tighter” beam for guidance. The SARH system needs only one radar set to a wider pattern.

38. SARH systems use continuous-wave radar for guidance. Even though most modern fighter radars are pulse Doppler sets, most have a CW function to guide radar missiles. A few Soviet aircraft, such as some versions of the MiG-23 and MiG-27, used an auxiliary guidance pod or aerial to provide a CW signal.

39. SARH missiles require the tracking radar to lock on to the target and then illuminate it for the entire duration of the missile's flight. This could leave the launch aircraft vulnerable to counterattack, as well giving the target's electronic warning systems time to detect the attack and engage countermeasures. Recent-generation SARH weapons have superior electronic counter-countermeasure (**ECCM**) capability, but the system still has fundamental limitations. The modern trend is towards missiles such as AIM-120 AMRAAM or MICA, which use an initial lock-on by the firing aircraft to illuminate the target and then steer the missile to the target area by inertial guidance before activating a terminal guidance system (based on active radar or infrared homing) for the final attack. Some of these weapons, like AMRAAM, allow the firing aircraft to update the missile with mid-course updates via datalink, but otherwise allow the weapon to be "fire and forget" (a.k.a. "launch and leave"), allowing the attacker to move on to other targets.

40. Examples of Semi Active Radar Homing Missiles are:

a. The USA's helicopter launched Brimstone missile (ASM).The missile is an extremely lethal system, it is a "fire and forget" weapon and can be programmed to adapt to a particular mission. For example it can be programmed to seek targets beyond a certain point (i.e. over fly friendly forces) and not to seek targets beyond another point. The resolution offered by the missile's seeker, the millimetric wave (MMW) radar, allows the weapon to "image" a target. Embedded algorithms allow target discrimination according to this image, allowing the weapon to attack specific targets, for example armoured vehicles only and ignore other targets, e.g. cars or structures. Also the MMW radar is less susceptible to poor weather conditions, smoke or fog than conventional radar.

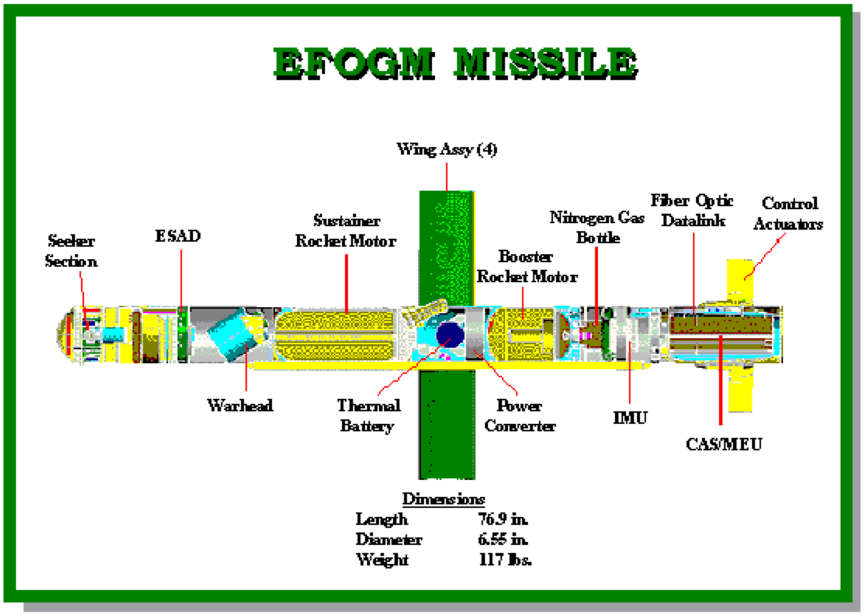
b. USA’s Hellfire II is the optimized version of the laser family of Hellfire missiles. The Longbow Hellfire Modular Missile System is an air-launched, radar aided, inertially guided missile that utilizes millimeter wave radar technology.

Optical guidance

41. In optical guidance the missile is guided by a TV camera in the nose of the missile which remains connected to the launcher by spooling out a fiber optic cable thinner than a fishing line. A soldier watching a video screen guides the missile with a joystick and crashes it into the target. It can strike armored vehicles, helicopters or any tactical target within 10 miles.

42. Examples of Optically guided missiles are:

a. Used in a more suitable form is the EFOG-M built by the United States. EFOG-M is basically a long-range TOW Anti-Tank Guided Missile. It flies a high trajectory and employs a TV camera in the nose of the missile which remains connected to the launcher by spooling out a fiber optic cable.



b. The YMGM-157B is a terminal homing missile that utilizes a fiber optic data link to transmit and receive command and sensor data with a mobile fire unit to find and defeat threat targets masked behind hills, foliage or in urban settings. The missile employs a high resolution infrared video camera in the nose of the missile to provide the gunner with an unobstructed view of the surrounding terrain from the missile's perspective. The gunner can pan the missile's seeker to investigate targets of opportunity as the missile flies a non-ballistic flight path around or over obstructing terrain to pre-selected target areas. Once launched, the missile utilizes inertial instruments to automatically navigate the missile along a preprogrammed flight path up to 15 kilometers in length. The gunner is utilized as a discriminating man-in-the-loop sensor to identify and designate targets and to assist in refining the missile's aim point on vulnerable locations of the target. A top attack trajectory, exceptional terminal precision and a shaped charge kill mechanism work together as an extremely lethal combination against heavily armed targets masked behind cover. No other Army missile provides this kind of man-in-the- loop capability to minimize fratricide while inflicting precise kills in an integrated battlefield.

c. LOSAT by USA

d. The new Israeli anti tank guided missile "Gil" which is a third generation, "fire and forget, missile. The "Gil" is able to receive data subsequent to its launch, and is capable of switching targets while in flight.The "Gil" is one of the most advanced missiles in the world, and was developed by the Rafael arms industry in cooperation with the IDF during the 1990's.The warhead seeker is electro-optical (TV) and enables tracking as well as pinpoint target acquisition. In addition, the "Gil's" fiber-optic communcations system allows for the collection of vital intelligence gathering, the ability to seek hidden targets, and prevents firing against targets which have been previously destroyed.

e. NTD (Spike-Er) of Israel.

f. Polyphem built by EU.

3. Active Radar Homing This system uses a radar on the missile to provide a guidance signal. Typically electronics in the missile keep the radar pointed directly at the target, and the missile then looks at this “angle off” its own centerline to guide itself.

4. Track-Via-Missile (TVM) is like a hybrid between command guidance, semi-active radar homing and active radar homing. The missile picks up radiation broadcast by the tracking radar which bounces off the target and relays it to the tracking station, which relays commands back to the missile.

A more unusual example of homing guidance is the retransmission method. This technique is largely similar to command guidance but with a unique twist. The target is tracked via an external radar, but the reflected signal is intercepted by a receiver

onboard the missile, as in semi-active homing. However, the missile has no onboard computer to process these signals. The signals are instead transmitted back to the launch platform for processing. The subsequent commands are then retransmitted back to the missile so that it can deflect control surfaces to adjust its trajectory.

This method is also sometimes called "track via missile" (TVM) since the missile acts as a conduit of tracking information from the target back to the ground control station. The advantage of TVM homing is that most of the expensive tracking and processing hardware is located on the ground where it can be reused for future missile launches rather than be destroyed. Unfortunately, the method also requires excellent high-speed communication links between the missile and control station, limiting the system to rather short ranges. Retransmission homing guidance is used on the Patriot surface-to-air missile though it can be used very effectively in anti tank guided missiles also.

Imaging Infra-Red Homing / Heat Seeking Missiles

43. Infra-red homing refers to a guidance system which uses the infra-red light emissions of a target to track it. Missiles which use infra-red seeking are often referred to as “heat-seekers”. Infra-red is just below the visible spectrum of light and is radiated mostly by hot bodies. Many objects such as people, vehicle engines and aircraft generate and retain heat and as such, are especially visible in the infra-red wavelengths of light compared to background elements. As their name implies, heat-seeking missiles home on to the hot areas of a target. The target will usually both reflect and emit infra-red radiation, which propagates through the atmosphere. This radiation is detected by the missile’s seeker head, which, if the conditions are right, will then provide the guidance with the relative position of the target enabling the weapon to home in and destroy the target.

44. Most infra-red guided missiles have their seekers mounted on a gimbal. This allows the sensor to be pointed at the target when the missile is not. This is important for two main reasons. One is that before and during launch, the missile can’t always be

pointed at the target. Rather, the pilot or operator points the seeker at the target using the radar, a helmet-mounted sight, an optical sight or possibly by pointing the nose of the aircraft or missile launcher directly at the target. Once the seeker sees and recognises the target, it indicates this to the operator who then typically “uncages” the seeker (which is then allowed to follow the target). After this point the seeker remains locked on the target, even if the aircraft or launching platform moves. When the weapon is launched, it may not be able to control the direction it points until the motor fires and it reaches a high enough speed for its fins to control its direction of travel. Until then, the gimballed seeker needs to be able to track the target independently.

45. Finally, even while it is under positive control and on its way to intercept the target, it probably won’t be pointing directly at it; unless the target is moving directly toward or away from the launching platform, the shortest path to to intercept the target will not be the path taken while pointing straight at it, since it is moving laterally with respect to the missile’s view. The original heat-seeking missiles would simply point towards the target and chase it; this was inefficient. Newer missiles are smarter and use the gimballed seeker head combined with what’s known as “proportional guidance” in order to avoid oscillation and to fly an efficient intercept path.

46, The guidance system itself commonly consists of a window/filter assembly in the nose of the weapon, this serves to select only particular wavelengths of IR, these then enter an optical modulation system, a reticule or chopper, which enables a detector element to receive IR emissions from the target, while rejecting clutter. The output from the detector is processed by signal detection electronics which separate target position carrying information from the clutter present, a computer then employs proportional navigation to generate guidance commands.

47. Very modern heat-seeking missiles utilise imaging infra-red (**IIR**), where the IR/UV sensor is actually a focal planar array sensor which is able to "see" in infra-red, much like the CCD in a camera. This requires much more signal processing but can be much more accurate and harder to fool with decoys. In addition to being more flare-

resistant, newer seekers are also less likely to be fooled into locking onto the sun, another common trick for avoiding head-seeking missiles.

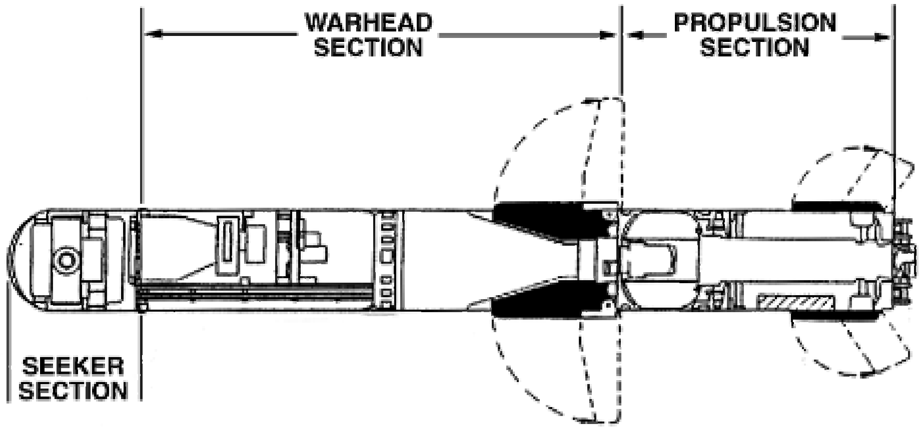
48. Before imaging infra-red sensors there was also the question of sensor modulation; earlier seekers used amplitude modulation (AM) to determine how far off-center the target was and thus how hard the missile had to turn to center it, but this lead to increased error as the missile approached the target and the target's image became relatively larger (creating an artificially stronger signal). Switching to frequency modulation (FM) solved this problem, which is better able to discriminate the distance without being further confused by the image size.

49. Examples of Infra-red or heat guided missiles are:

a. **Milan I-III.** Milan is a second generation anti-tank weapon, the result of a joint development between France and West Germany with British Milan launchers and missiles built under license in the UK. The Milan consists of two main components, the launcher and the missile; these are simply clipped together to prepare the system for use. On firing, the operator has only to keep his aiming mark on the target and the Semi Automatic Command to Line of Sight (SACLOS) guidance system will do the rest. The missile is guided for its entire trajectory by an automatic device of remote control using the infra-red radiation (MILAN 1) or an electronic-flash lamp (MILAN 2). Milan, which was initially developed for the French and German infantry, is now in service in 41 countries all over the world. The new-generation weapon MILAN 3, armed with a tandem warhead with a new firing post with jam-resistant pulsed-beacon infrared guidance, has been in production since 1996.

b. Nag (Hindi for "cobra") anti-tank guided missile built by India. The Nag missile uses IIR Cadmium Zinc Telluride as heat detector. Nag is India's third generation "fire and forget" anti-tank missile. It is all weather, top attack missile with a range of 4 to 6 km. The missile uses an 8 kg tandem HEAT warhead capable of defeating modern armour including ERA (Explosive Reactive Armour) and composite armour. Nag uses Imaging Infra-Red (IIR) guidance with day and night capability. Mode of launch for the IIR seeker is LOBL (Lock On Before Launch). Nag can be mounted on an infantry vehicle; a helicopter launched version is will also be available with integration work being carried.

c. US made Javelin have secondary capabilities against helicopters and ground-fighting positions. It is equipped with an imaging infrared (I2R) system and a fire-and-forget guided missile. The Javelin's normal engagement mode is top-attack to penetrate the tank's most vulnerable armor. It also has a direct-attack capability to engage targets with overhead cover or in bunkers. Its "soft launch" allows employment from within buildings and enclosed fighting positions. The soft launch signature limits the gunner's exposure to the enemy, thus increasing survivability. JAVELIN is also much more lethal than DRAGON. It has a top attack dual warhead capability which can defeat all known enemy armor systems.



d. XATM-5 Light Anti-Tank Missile [Mat] Infrared (IR) Guided Submunition built by Japan.

e. The Next-Generation Light Anti-Armour Weapon (NLAW) Britain

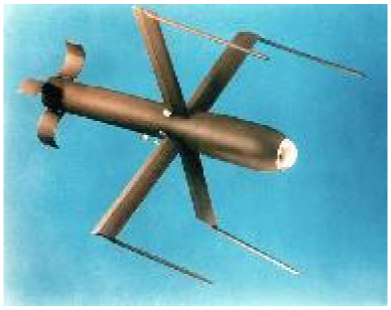
(Acquired by Taiwan, Lithuania, Jordan, Australia, New Zealand, Norway, Ireland and Canada, United Arab Emirates, Oman.)

<u>Acoustic And Infrared (IR) Guided Submunition</u>.

50. The USA’s Brilliant Anti-Armor Submunition (BAT) The BAT is a self-guided submunition that uses on-board sensors to seek, identify, employ a top attack engagement profile, and destroy moving tanks and other armored combat vehicles. It uses an acoustic sensor to seek out its armor targets, and infra-red sensor to engage the vehicles. The BAT is an acoustic and infrared (IR) guided submunition that autonomously searches for, tracks and defeats armored and critical mobile targets. The BAT is a propulsionless, aerodynamically controlled vehicle (glider). The BAT is delivered to the target vicinity by the Army Tactical Missile System (Army TACMS), which is launched from the M270 Multiple Launch Rocket System (MLRS). As such,

BAT is part of the MLRS Family of Munitions (MFOM). The submunition is designed to provide capability to attack deep, high-payoff and time critical targets.

The dual mode (acoustic/IR) seeker and gliding capability accommodate large target location uncertainties due to such efforts as target motion, configuration or orientation; winds, delivery vehicle accuracy or delivery patterns. This flexibility also accommodates variability in the decision-to-shooter timeline and obviates the need for inflight targeting updates to the Army TACMS.



<u>Semi Automatic Radio Command Guidance</u>.

51. These missiles are not wire-guided but use radio instead of wire to transmit commands from the operator to the missile. The system is based on the old radio guided missile system but this is semi automatic, means that the entire operator has to do is to keep the sight's cross hair at the target and the missile would itself home on to the target. The missile in this system is highly robust against hostile jamming. The radio guidance system is encoded and the pulsed infrared tracking signal provides protection against active jamming.

52. Examples of this type of guided weapons are:

a. The Russian Shturm Self Propelled Anti-Tank Guided Missile uses an automatically loaded launcher, which operates in direct visibility conditions. The missile uses a semi-automatic radio-command guidance system, which is highly robust against hostile jamming. The radio

guidance system is encoded and the pulsed infrared tracking signal provides protection against active jamming.

b. The Ataka missile, which carries the Russian designation 9M120 and NATO designation AT-9, is an upgraded version of the Shturm missile. It is fired from existing Shturm launch vehicles. The Ataka has a longer range of 6,000 and is slightly heavier. Warhead options include a tandem shaped-charge HEAT (high explosive anti-tank) warhead for deployment against advanced main battle tanks provided with explosive reactive armour (ERA), a blast warhead to defeat light armoured vehicles, field fortifications and small ships and a rod warhead to engage helicopters and other air targets. The Ataka missile also equips the Mi-28N combat helicopter.

c. The Russian At-8 Songster, tank gun fired, radio frequency guiding link also held with China.

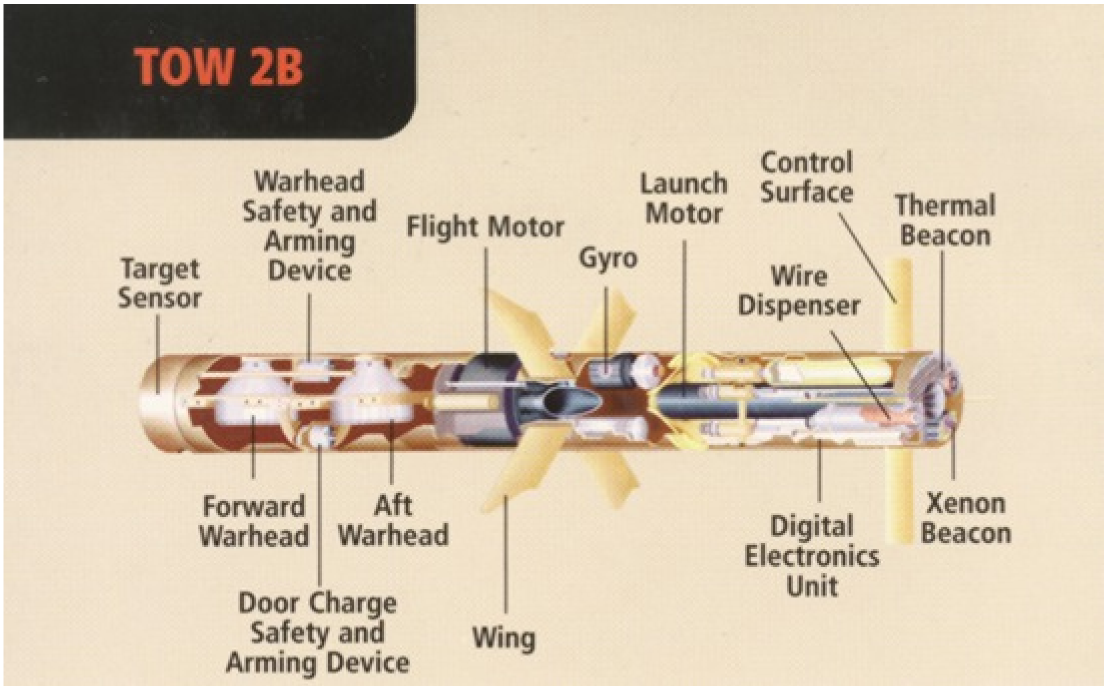
d. Russian AT - 6 SPIRAL anti-tank guided missile which is similar to the AT-2 Uprated SWATTER except for it being wire less.

Latest Trends in TOW Weapon Systems

53. **Tandem Warhead**. For penetration of tanks protected with explosive reactive armour (ERA), The United States took the early lead with the new version TOW 2A which is equipped with a tandem warhead. A small disrupter charge detonates the reactive armour and allows the main shaped charge to penetrate the main armour.

54. **Top Attack Missile**. TOW 2B, operates in a "flyover shoot down" top attack mode, unlike other versions which are direct attack. It features a dual-mode target sensor which includes laser profilometer and magnetic sensor, and new warhead section. It resembles the TOW 2A but without the extendible probe, and is armed with two explosively formed tantalum penetrator (EFP) warheads. The EFP warheads

detonate simultaneously, one pointing downwards, the other slightly offset to give an increased hit probability. The warhead material is designed to generate pyrophoric effects within the damaged target.



55. **Helicopter Mounted TOW**. An extended range TOW 2B missile, TOW 2B Aero, has a range of 4.5km, which is achieved in only a few seconds longer than the flight time of TOW 2B to 3.75km. Two modifications are made to the TOW 2B. A longer wire is required for the longer range and a new aerodynamic nose has been fitted to allow stable, controllable flight to the extended range, while using the current propulsion system.

56. **Wire Less TOW.** Another development of the TOW 2B, the wireless TOW RF has been successfully demonstrated. TOW 2B RF is modified with a one-way, stealthy radio frequency command link which dispenses with the wire link and gives a range of 4.5km.

57. **Fire And Forget TOW.** Yet to come in production is the new version of TOW i.e. Wireless TOW Fire & Forget missile. The US Army had cancelled the project in 2002. TOW-FF was to have an advanced imaging infrared staring focal plane array seeker. It is employed either mounted or dismounted from the TOW launcher. Tactical employment will remain the same as the current TOW with adjustments made for TOW F&F's characteristics. TOW F&F's primary mode of target engagement is fire-and-forget. It will have a secondary mode of attack that together with the fire-and-forget mode will enable the operator to hit any target acquired within range of the missile. First unit equipped is FY05 pending future funding of the program.

58. **Follow On To TOW (FOTT).** The FOTT will be comprised of the encased FOTT missile and associated platform. Key FOTT missile requirements are:

a. compatibility with all TOW ground platforms;

b. fire and forget primary mode of operation with an alternate (semi-automatic command to line-of-sight) mode as backup;

c. increased range, lethality and platform survivability;

d. modular design for future growth and shelf-life extension; and

e. backward compatibility with TOW missiles.

Future growth will be accommodated by the FOTT modular design and by transition of applicable technologies from on-going tech base programs. FOTT's precision engagement capability will enhance the Army's ability to dominate the ground maneuver battle.

59. In addition to these latest trends there are other trends which may be incorporated in missiles, these are the GPS guided and the anti radiation missile used against actively protected tanks but it would not be a cost efficient weapon as these systems may be used for cruise and other missiles but not the anti tank missiles.

Indian Anti Tank Missiles

a. **Nag**. It is a third generation anti tank missile with a range of 4 Kilometers. Indians have conducted three user test trials of anti tank Nag Missile at School of Armour, Ahmednagar on 2 March 2003.It was claimed that all three tests achieved range of 4 Kilometers in top attack mode. Both in day as well as night trials hitting target with 100% accuracy. The missile has been test fired 39 times prior to these trials. Nag, the third generation anti tank missile, will replace the Milan anti tank missile. The missile is capable to counter contemporary advance of armour specially the reactive types of armour. The missile is initially guided by radar mounted on the carrier and terminal guidance is by infrared imaging system. BMP-1 vehicle is being used for launching these missiles. A helicopter launched version of the missiles is also under development. Timeframe for induction of Nag Missile in army is not clear. General characteristics of the missile are as follows: -

(1) **General**. 3rd generation “Fire and Forget” anti tank missile.

(2) **Guidance**. Initial guidance from launchers by on board millimetric wavelength (active) and terminal guidance from imaging infrared seekers (passives).

(3) **Launcher**. BMP-1.

(4) **Range**. 4 Kilometers.

(5) **Warhead**. Tandem HEAT

Some of the salient features of the missile are that it uses an 8 kg tandem HEAT warhead capable of defeating modern armour including ERA (Explosive Reactive Armour) and composite armour. Nag uses Imaging Infra-Red (IIR) guidance with day and night capability. Mode of launch for the IIR seeker is LOBL (Lock On Before Launch). Nag can be mounted on an infantry vehicle; a helicopter launched version will also be available.

Separate versions for the Army and the Air Force are being developed. For the Army, the missiles will be carried by specialist carrier vehicles (NAMICA) equipped with a thermal imager for target acquisition. NAMICA is a modified BMP-2 ICV license produced as “Sarath” in India. The carriers are capable of carrying four ready-to-fire missiles in the elevatable observation/launch platform with more missiles available for reload within the carrier. For the Air Force, a nose-mounted thermal imaging system has been developed for guiding the missile’s trajectory. The missile has a complete fiberglass structure and weighs around 42 kg. Further versions of the missile may make use of an all weather MMW seeker as an additional option.

b. **<u>Konkurs M Laser Guided Anti-Tank Missile KBP (Russia</u>**). Konkurs-M anti-tank missile which is locally produced in India is a second generation ATGM. It is carried on small platforms or APCs and can be rapidly dismounted for man portable land based operation. The missile can fly over water and at heights above 3,000 meters.

c. **<u>Milan-2 and Milan 2-T</u>** Milan is a second generation anti-tank weapon. The Milan consists of two main components, the launcher and the missile; these are simply clipped together to prepare the system for use. On firing, the operator has only to keep his aiming mark on the target and the Semi Automatic Command to Line of Sight (SACLOS) guidance system will do the rest. The missile is guided for its entire trajectory by an automatic device of remote control using the infra-red radiation (MILAN 1) or an electronic-flash lamp (MILAN 2). The difference between Milan 2 and Milan 2-T is the kind of warhead and the penetration capacity. Some of the characteristics of the missile are:

(1). <u>Time of Flight</u>**:** To maximum range - 12.5 sec.

(2). <u>Maximum Range</u>**:** 2000 meters.

(3). <u>Chance of Hit</u>**:** From 0 to 250 metres - 75% average.
From 250 to 2000 metres - greater than 98%.

d. **<u>9K11 Malyutka (AT-3 Sagger)</u>** The 9K11 Malyutka can be employed as a man-packed missile, on vehicles or helicopters. The AT-3a/b versions use manual-command-to line-of-sight (MCLOS) guidance where the operator literally flies the missile down his line of sight to the target. The missile is also slow; it takes 25 seconds to reach its maximum range of 3000 metres. The AT-3c version was refitted using semi-automatic command line of sight guidance (SACLOS) to serve as an interim until the AT-5 Spandrel and AT-6 Spiral came in to widespread service. This ATGW has a high explosive anti-tank warhead and has an armour penetration of 400mm.

e. **<u>9K11 Fagot (AT-4 Spigot)</u>.** The AT-4 is a tube-launched, wire-guided, command-to-line-of-sight, semi-automatic ATGM system, similar in many respects to the American TOW system. The system consists of three major components; the missile, the launch tube and the missile launcher. The tripod-mounted launcher for ground-launched employment has a periscope sight attached to its left side. The sight and missile tracker comprise a single unit, which is mechanically attached to the launch tube connecting the rail so both move together in elevation. The crew loads the missile by sliding the tube onto the launch supports from the rear until the electrical contacts and a mechanical catch engage, then the system is ready for launch. The missile was originally designed as a ground launched weapon system. However, turrets of the BMP-1 and others can mount the AT-4b launcher. This ATGW has an improved sustained motor which increases the maximum range to 3 km and a HEAT (High Explosive Anti-Tank) warhead, with armour penetration of 500mm. The missile's extremely narrow field of view makes it more difficult to decoy, since the decoy source must be inside the field of view. SIPRI {Stockholm International Peace Research Institute} reported that between 1992-1994, around 900 missiles were licensed produced.

f. **<u>9K113 Konkurs (AT-5 Spandrel)</u>.** The 9K113 *Konkurs* is considered to be the equivalent to the American TOW missile. This ATGW is similar to the AT-4 in most respects except in it's weight and maximum range, with the latter being 4 km. The AT-5 is intended for use on vehicles only. It has a HEAT (High Explosive Anti-Tank) warhead, with armour penetration of 600-700mm. SIPRI {Stockholm International Peace Research Institute} reported that between 1992-2001, around 4300 missiles were licensed produced.